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(54) control system for light emitting device.

(57) The present invention relates to a control system for a light emitting device (14) comprising a control circuit (15) for controlling the emission of light from the device, a digital to analog converter (23) for generating analog signals for supplying to the control circuit (15) in order to control the intensity of the emitted light, means (20) for supplying digital signals to the digital to analog convertor in accordance with the required intensity of the emitted light, and calibrating means for calibrating the control system to account for variations in the parameters or the operational state of the system.

According to the invention the control system is characterised in that the calibration means comprises means (20) for varying the digital signals supplied to the convertor until the intensity of the light emitted from the device is at a first, minimum level and storing the value of the digital signals as a first digital value, means (20) for varying the digital signals supplied to said convertor until the intensity of the light emitted from the device is at a second, maximum level and storing the value of the digital signals as a second digital value, and calculating means (20) for calculating from the stored digital values the change of light intensity (E) represented by a unit change of digital signal value.

EP 0 467 616 A2

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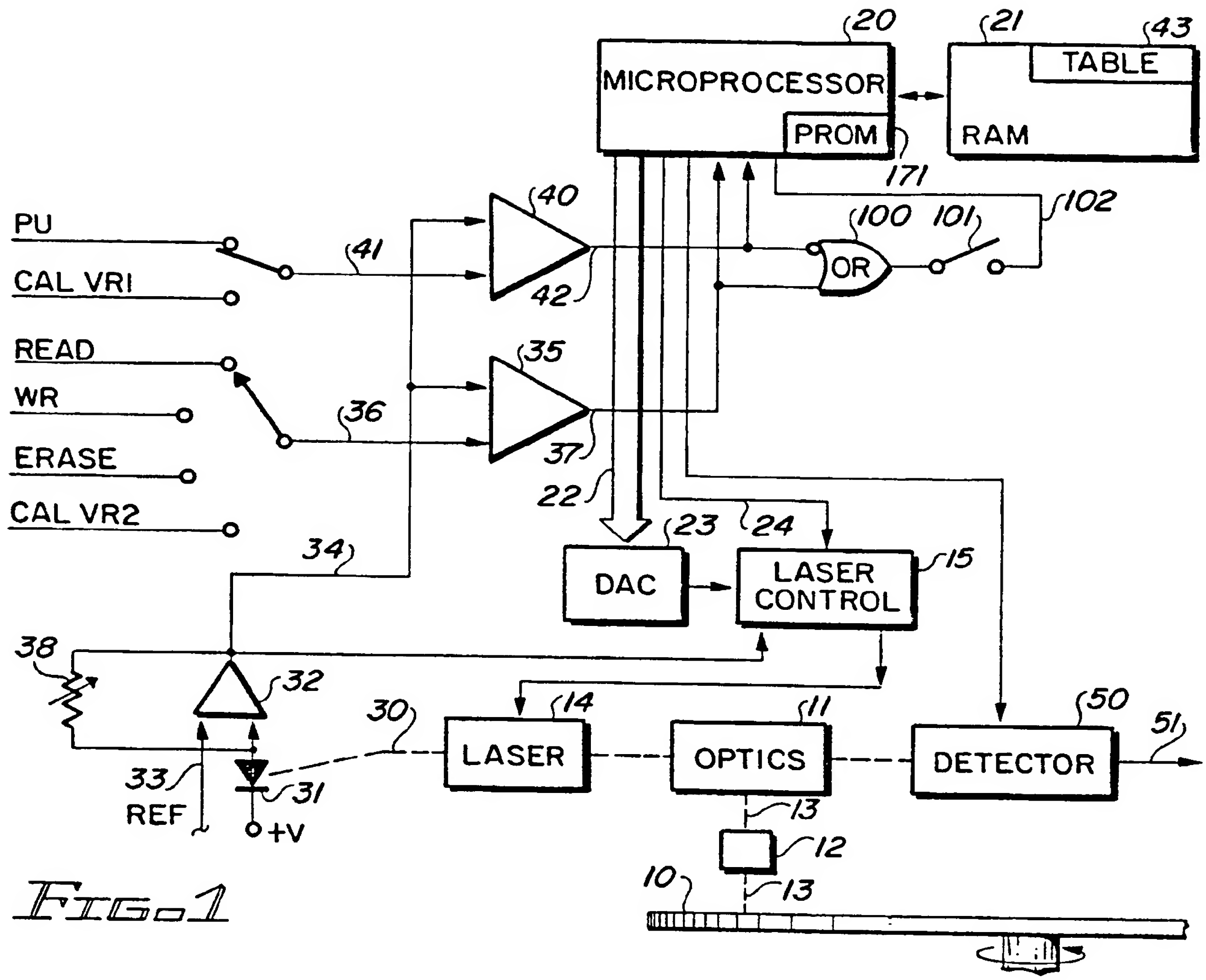
MICROPROCESSOR
PROM
TABLE
RAM
PU
CAL VR1
READ
WR
ERASE
CAL VR2
OR
DAC
LASER CONTROL
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+V
20
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FIG. 1

The present invention relates to control systems for lasers or other light emitting devices and more particularly to control systems for solid lasers used in optical data storage devices.

Lasers, particularly solid state lasers, have been used for years for generating light beams for use in recording and reading and erasing data on optical storage media. It has been found that the control systems and the laser itself are both subject to unintended changes in their operating parameters. Further, the operating parameters of storage media also vary from one medium to the next; such variations are significant when using so-called removable optical storage media.

It is, of course, common practice to calibrate the laser control systems to operate with a given optical medium; such calibration usually involves analysing the laser light beam intensity at the optical storage medium, then setting the operation of the laser control circuits to match a predetermined or desired light intensity at the optical storage medium. Such control systems have included digital to analog converters (DAC) for enabling the data recording, reading, and erasing operations on an optical storage medium.

Laser operations have been controlled independently of the optical medium. For example, US -A- 4,709,369 shows establishing a DC voltage which represent the peak value of light pulses out of a laser diode independent of the modulation pattern of the light pulses. This patent shows an integrative feedback loop which compares the desired power of the laser with the actual output from the conditioning means to establish an output current to cause the laser diode to supply light pulses of the desired value. The conditioning means includes a sample and hold circuit operative in association with an integrator feedback loop to perform at a rate as if the modulated or chopped light from the laser diode were continuously on. The adjustment of the laser is made by human operator. It is desired to eliminate the need for a human operator by automatically calibrating and adjusting the laser output. US -A- 4,503,467 shows a digital to analog converter driven by an increasing counter for increasing the digital to analog converter output in a step-wise manner from a lower-limit value to an upper-limit value. Comparators compare the output signals of the light receiving units, which are in a row of light receiving units, with an analog reference signal which represents darkness or no light. Memories receive the digital signal and are controlled by the comparators to store instantaneous digital values when the corresponding comparators change their states i.e., capture the numerical value used to generate a predetermined analog value. It is desired to provide for a faster calibration technique not involving the use of digitised numerical values until after the calibration has been completed.

The object of the present invention is to provide an improved control system for a light emitting device, for example a laser used in an optical data storage device.

The present invention relates to a control system for a light emitting device comprising a control circuit for controlling the emission of light from the device, a digital to analog converter for generating analog signals for supplying to the control circuit in order to control the intensity of the emitted light, means for supplying digital signals to the digital to analog convertor in accordance with the required intensity of the emitted light, and calibrating means for calibrating the control system to account for variations in the parameters or the operational state of the system.

According to the invention the control system is characterised in that the calibration means comprises means for varying the digital signals supplied to the convertor until the intensity of the light emitted from the device is at a first, minimum level and storing the value of the Digital signals as a first digital value, means for varying the digital signals supplied to said convertor until the intensity of the light emitted from the device is at a second, maximum level and storing the value of the digital signals as a second digital value, and calculating means for calculating from the stored digital values the change of light intensity (E) represented by a unit change of digital signal value.

In a preferred embodiment of the invention, a digital to analog converter controls the output light intensity of a laser diode, such as for recording signals on an optical disk. Sensing means senses the laser beam or its calibration window output. The laser power for recording is calibrated by initially setting the digital to analog converter (DAC) to supply a drive to the laser at a predetermined minimum laser power. The numerical input to the DAC is increased until an analog comparison of the laser beam intensity reaches a predetermined value above the minimum laser power level. At that point, the calibration steps of the DAC and laser circuits steps. A calculation in a microprocessor subtracts the minimal power value from the power reference value, then divides the number of the DAC setting between the two power levels to obtain a DAC efficiency which is laser output power level change per DAC unit-value input change. Then the power levels desired for operating the laser are determined. The relationship of each DAC unit-value input for obtaining absolute laser output value is then determined by calculations.

In another aspect of the invention the comparators used for determining the minimum power level and the maximum or reference power level are then used during normal day to day operations of the laser for detecting under power and over power conditions.

In order that the invention may be more readily understood an embodiment will now be described with reference to the accompanying Drawings in

which:

Fig. 1 is a simplified block diagram of an optical disk data storage system embodying a laser control system according to the invention,

Fig. 2 is a simplified flowchart of the operation of the laser control system illustrated in Fig. 1,

Fig. 3 is a circuit diagram showing the operation of the calibration, over power and under power operations of the laser control system illustrated in Fig. 1,

Fig. 4 is a simplified chart of the operation of the initial calibration of the control system illustrated in Fig. 1,

Fig. 5 is a chart of the operation of over or under power error detection in the control system illustrated in Fig. 1, and

Fig. 6 is a diagrammatic illustration of an optical recording disk on which power level and control level information is recorded and which is usable with the control system illustrated in Fig. 1.

Referring now more particularly to the accompanying drawings, like numerals indicate like parts and structural features in the various Figures. A magneto-optical data storage disk 10 is suitably mounted for rotation in an optical disk data storage system (mechanical details not shown). Other types of optical media may alternatively be employed while practising the embodiment to be described. An optical system 11, which includes the usual beam splitters and the like, supplies a light beam through objective lens 12 over light path 13 and receives reflected light from disk 10 over the same path and objective lens 12. Laser 14 supplies a light beam through optical system 11 to disk 10 as controlled by laser control unit 15, as later detailed in Fig. 3. The Fig. 1 illustrated data storage system is under the control of a programmed microprocessor 20 which has a random access memory (RAM) 21. Microprocessor 20 supplies a digital value over cable 22 to digital to analog converter (DAC) 23. DAC 23 supplies an analog signal to laser control circuit 15 for determining the intensity of the beam of light emitted by laser 14 to optical system 11. The laser output light beam intensity in modulated in accordance with data as supplied by microprocessor 20, or other data handling circuits. Line 24, extending from microprocessor 20 to laser control circuit 15, signifies additional mode control for controlling the laser control circuit 15, all as will become apparent.

laser 14 is controlled in intensity by a feedback circuit in laser control circuit 15. Laser 14 emits an auxiliary light beam over light path 30 to a photo diode 31. Photo diode 31 varies the amplitude of the output current in accordance with the intensity of the light over path 30, as is known. Transimpedance amplifier 32 responds to the diode 31 output current amplitude compared with a reference value on line 33 to supply signals over line 34 which are indicative of laser 14 output beam intensity. Potentiometer 38 adjusts the gain of transimpedance amplifier 32 for achieving a target read output power level. This adjustment effects a calibrated signal level on line 34 in volts per watts. As a result, the signal level on line 34 represents the absolute light power output of laser 14. Laser control circuit 15, under normal operations, responds to the signal level on line 34 to maintain the laser 14 operation at predetermined intensity values, as is known.

As will now be described, additional circuits are provided for processing the line 34 signal for enabling automatic calibration of DAC 23 such that numerical values on cable 22 accurately represent a desired output light beam intensity from laser 14. It is expected that DAC 23 will be calibrated each time a new disk 10 is inserted into the storage system and/or during predetermined error recovery procedures. DAC 23 is calibrated based upon increases in laser 14 output light beam intensity between a minimum or safe value and a maximum calculated predetermined operational value. Such maximum value is predetermined based upon the operating range of the optical medium 10 as well as the laser 14 operating limits.

A first analog comparator 40 receives at one input the line 34 signal indicating the laser 14 output beam light intensity. On line 41 is a reference value indicative of the desired minimum or safe value CAL VR1. Comparator 40 supplies an inactive signal over line 42 to microprocessor 20 at all times unless the signal on line 34 indicates that laser 14 is emitting a light beam of intensity equal to or greater than the minimum value. At this time comparator 40 supplies an active signal over line 42 to microprocessor 20. Microprocessor 20 then stores the DAC 23 input value in table 43 for later calculating values to be used in controlling laser 14.

The microprocessor 20 programming, as later described, continuously increases the numerical value over cable 22 to thereby cause DAC 23 to actuate laser 14 to ever increasing power levels for increasing the output light intensity. This repetitive step by step increasing continues until comparator 35, constructed in the same way as comparator 40 and in which line 36 is connected to a CAL VR2 reference signal via switch 36, detects at its first input a signal on line 34 which is greater in amplitude than the reference signal on line 36 representing a maximum or desired reference output light intensity of laser 14. Comparator 35, when sensing that the line 34 signal is less than the reference signal on line 36, supplies an inactive signal over line 37 to microprocessor 20. As soon as comparator 35 determines that the line 34 signal exceeds the reference signal on line 36, then an active signal is supplied over line 37 to microprocessor 20, whereupon microprocessor 20 stores that DAC 23 input value in table 43. At this point, microprocessor 20 has completed the measurement portion of the initial DAC 23 calibration.

It is to be understood that microprocessor 20 also controls all aspects of the illustrated optical disk data storage system. For example, detector 50, which detects the data sensed from medium 10, is also controlled to supply the data signals over line 51 as is well known. Detector 50 is an optical detector which is optically coupled through optical system 11.

Fig. 2 illustrates in flow chart form the operations described with respect to the Fig. 1 illustrated data storage system. At step 55 microprocessor 20 sets the erase mode for operating the laser 14. Erase mode merely means that laser 14 is continuously ON at a constant laser output intensity, i.e., such as used for erasing signals recorded on magneto-optic medium 10. At step 56, microprocessor 20 supplies a number over line 22 for setting DAC 23 to a lowest or minimum output light intensity level for laser 14. At step 57, microprocessor 20 examines the signal state of line 42 to determine whether or not the measured light intensity from laser 14 over light path 30 is exceeding the minimum power limit Pmin indicated by the signal on line 41. Normally during a first step the limit is not exceeded where upon the DAC 23 value is increased at step 58. Step 57 is then re-entered and steps 57 and 58 are repeated until comparator 40 determines that the limit for the calibration has been exceeded. At this time, microprocessor 20, in step 60, stores in table 43 the value sent to DAC 23, "DACmin", the DAC input value for actuating laser 14 to emit light at "Pmin" power or intensity level.

The procedure used in above-described steps 57 and 58 is used in steps 61 and 62 for determining the maximum laser power output level. At step 61, microprocessor 20 senses the signal state of line 37 (comparator 35 output). If the line 37 signal is in an inactive state, then the line 34 signal is less that the limit amplitude supplied over line 36, i.e. the laser 14 output light intensity is less than the desired maximum level. The DAC 23 input value is increased in step 62 and the steps 61-62 are repeated until comparator 35 supplies an active signal to line 37. When the level "Pmax" is exceeded as detected at step 61, microprocessor 20 saves the DAC 23 input value in table 34 as DACmax, the DAC input value resulting in a laser 14 output light power of Pmax.

The microprocessor then performs step 64 which first calculates the power range represented by the actions of comparators 40 and 35 by subtracting the minimum power level Pmin represented by comparator 40 from the maximum power level Pmax represented by the action of comparator 35 (Pmax - Pmin). Microprocessor 20 then calculates the DAC 23 range determined by comparators 35 and 40 by subtracting the DAC 23 number DACmin stored from the execution of machine step 57 from the DACmax value. In step 64, the calculated power range (Pmax-Pmin) is divided by the DAC 23 range (DACmax - DACmin) to obtain a value E of power level change per each DAC 23 step or change of a unitary value in numerical control on line 22. Such value E can be considered as representing the total efficiency of the laser control circuit 15 and the laser 14.

Then in step 65, microprocessor 20 uses the value E or efficiency for calculating the various settings for DAC 23 for data recording and erasing operations. In step 65 the DAC input digital value for recording is calculated by adding the DACmin value to a respective calculated recording or erasing power level increment. In the equation below, "P" signifies either the desired recording or erasing power level;

$$\frac{P-Pmin}{E}; \quad (1)$$

Therefore, the DAC 23 setting for any desired power level P is:

$$DAC = DACmin + [(P-Pmin)/E] \quad (2)$$

The DACmin can be selected to be zero which eliminates steps 57 and 58. Step 56 sets DACmin to zero which is Pmin. In this instance, the calculations of step 65 are simplified in that DACmin = 0 which reduces equation (2) to:

$$DAC = \frac{P - Pmin}{E} \quad (3)$$

and the efficiency equation to:

$$E = (Pmax - Pmin)/DACmax \quad (4)$$

The efficiency E is affected by the operation of diode 31, laser 14, amplifier 32 and laser control circuit 15 as well as of DAC 23 itself. Changes in "E" can indicate changes in any of these parameters. Repeated E measurements are requirements for the system maintenance and operation.

The values calculated from equations (2) or (3) are then stored in table 43 for use by microprocessor 20 during normal operations. During a data recording operation, the value calculated at step 65 is used to change the state of medium 10 and the area currently being scanned by the laser beam travelling over path 13. In between the recording steps i.e., to record "zeros" or no changes, the read output laser light power level is used. Now the data recording system illustrated in Fig. 1 is prepared for normal operations as indicated by step 66. At this point, comparators 35 and 40 are now used for detecting over power conditions and under power conditions of laser 14 beam emission as will be later described.

Referring next to Fig. 3, the details of laser control circuit 15 are shown. In laser control circuit 15 amplifier 70 receives a signal from line 34. A reference input at line 71 controls amplifier 70 during read operations. Resistor network 73 is coupled to reference voltages with the bias supplied to amplifier 70 over line 71 being varied by the read switch 72. The signal voltage amplitude difference between the line 34 and line 71 signals is the voltage error output between a desired read laser output power level and the actual laser output power level. Amplifier 70 amplifies this error voltage and supplies it through control switch 75

as closed via the signal from microprocessor 20 received over line 76. Switch 75 is closed for read operations. Capacitor 77 smooths the signal received from amplifier 70 and acts as a sample and hold capacitor when switch 75 is open. A second amplifier 78 buffers and amplifies the error signal for passing it through resistor 79 to a controlling transistor 80, which acts as a current control. A second transistor 81 has its base connected to the collector of transistor 80 for supplying a current from a reference source +V1 which flows through voltage shifting diode 82 thence to laser diode 14 for causing emission of light. The value of the current flowing through transistor 81 is the total value for the mode involved. For recording, this means a recording level of current flowing through laser diode 14 for actuating it to emit an output light beam having a power or intensity level for recording on a record medium. Between the writing or recording actions i.e., the recording of "zeros" or making no change in the record medium that has previously been erased, the current from transistor 81 is partially diverted through a transistor 86 to current sink 87. The value of the current flowing to the current sink is controlled by DAC 23, therefore controlling the laser 14 emission. A write data signal is supplied to switch 90, shown as a flip-flop. A transistor turn-off signal supplied over line 91 makes transistor 86 non-conductive. This action forces the current from transistor 81 to flow through the laser diode 14 for causing maximum emission of radiation, i.e. maximum light output. Simultaneously, the line 92 from the flip-flop 90 switches transistor 93 to current conduction for replacing the current in current sink 87 previously supplied by transistor 86. The result is the recording of binary "ones" on the record medium 10, such as by reversing the remanent magnetisation of the area scanned by the beam on path 13. When a "not write" signal is being supplied to flip-flop 90, the current conduction of transistors 86 and 93 is reversed for diverting current from transistor 81 to reduce the emission of light from laser 14.

During data reading operations, switch 75 being closed, a laser 14 control loop exists such that the line 34 signal (representing emitted laser light power or intensity) matches the line 71 signal (desired read laser output power or intensity level). Each time microprocessor 20 changes the DAC 23 input value, it closes switch 75 and sets flip-flop 90. Then transistor 86 becomes current conductive. This action changes the current amplitude in current sink 87 such that the amount of current being diverted from transistor 81 is also changed. Upon each change of input value to DAC 23, a time delay is required to allow the laser control servo loop described above to reach an equilibrium operating point. During this time delay, a change in the current flowing through transistor 81 takes place. During data recording or erasing modes, switch 75 is kept open to prevent the above described servo action from changing the laser drive current during recording or erasing.

Comparators 35 and 40 are used not only for calibrating the DAC 23 but also for detecting under and over power conditions by changing comparator reference values. Switch 105 has its output terminal connected to line 41 for controlling comparator 40. During the calibration phase, microprocessor 20, by signal on line 24 (not shown in Fig. 3), switches electronic switch 105 to line 107 such that the reference voltage VR1 is supplied over line 41 to comparator 40 for detecting the minimum power laser 14 output level. During normal operations, switch 105 is switched to line 106 which indicates a minimum power to be emitted by laser 14. Similarly, switch 110 has its output connected to line 36 as an input to switching comparator 35. During the calibration phase, line 111 is connected through switch 110 to line 36 for determining the maximum power calibration level indicated by VR2. During the read mode of operation, switch 110 couples line 112 which supplies a safe or maximum read amplitude indicating signal to line 36 for ensuring that the read laser light beam intensity is low enough to prevent any unintended erasure of recorded information in the area being scanned by the laser 14 light beam. In the write mode, the maximum power indication for the write mode on line 113 is supplied to line 36. This prevents over power of the laser 14. In a similar manner, but not required, is the erase level safe value signal on line 114 to be used during the erase mode.

If either of the switching comparators 35 and 40 supplies its respective signal during normal operations over lines 42 and 37, those signals are passed through logic OR circuit 100 through switch 101, which is closed only during normal operations, over line 102 to microprocessor 20. The signal on line 102 then interrupts microprocessor 20 to turn off the laser 14.

The two-level under power and over power protection handles the following conditions. If a sudden change occurs in any of the components, such as shown in Fig. 3, or a sudden obstruction of the optical path occurs due to debris, or other causes, such an occurrence is detected by the under power and over power detectors 35 and 40 during normal operating mode. Reduced transparency in the optical path 30 reduces the photo current from photo diode 31, as a result, laser controller 15 tries to increase the laser 14 current and thus its power intensity output when in fact such increase is not warranted. In this case, comparator 40 detects the under-power condition which results in microprocessor 20 turning off the laser power. If there is a sudden change such as one that occurs within 3 microseconds, a significant voltage excursion occurs at the output of amplifier 32 and is detected as either an under power condition by comparator 40 or an over power condition by comparator

35. Failure of circuit components within laser control circuit 15 can also cause various changes in the laser 14 operation all of which will be detected by the comparators 35 and 40 causing microprocessor 20 to turn off the laser for protecting recorded data. Slower changes in optical path efficiency, detector 31 efficiency laser 14 efficiency, control circuit 15 and others are detected by recalibration of DAC 23 efficiency as will be described.

The flow chart of Fig. 4 shows a sequence that microprocessor 20 executes for calibrating DAC 23 beginning at a initialisation time at line 129. At step 130, microprocessor 20 closes switch 75 for enabling the laser servo to change its operating power level as DAC 23 receives changes input values from the microprocessor. At step 131, write data input is kept inactive such that flip-flop 90 (Fig. 3) is kept in an inactive state. This flip-flop 90 state actuates transistor 86 to be current conductive and transistor 93 to be current non-conductive. At step 132, microprocessor 20 supplies the minimum digital value signals over cable 22 to DAC 23 (sets DAC 23 to minimum input value). At this time, the current in current sink 87 is subtracted from the transistor 81 collector current.

At step 133, a time delay allows the Fig. 3 illustrated control circuit 15 and the optical response to reach steady-state conditions reflecting the DAC 23 minimum input value. As a result, the transistor 81 collector current is changed such that the laser 14 output light power, represented by the signal on line 34, matches the desired level represented by the line 71 signal.

At step 134, microprocessor 20 opens switch 75 for holding the transistor 81 collector current at a constant value determined by the current DAC 23 digital input value. In step 135 microprocessor 20 activates the write data signal by setting flip-flop 90 to the active state. The flip-flop 90 active state forces transistor 86 to be current nonconductive and transistor 93 to be current conductive. At this instant, all the current from the collector of transistor 81 is supplied to laser diode 14 causing it to emit light at a maximum power level determined by DAC 23 setting. Microprocessor 20 then, at step 136, senses the comparator 40 output signal on line 42. If the comparator 40 signal is inactive (relatively negative, for example), as sensed by step 137, microprocessor 20 inactivates the write data (resets flip-flop 90) and in step 138 closes switch 75.

At step 139 the microprocessor 20 supplied input value on cable 22 is increased by a predetermined amount. This DAC 23 changed input is followed by a time delay 140 before the steps 134-137 are repeated until the comparator 40 supplies an active signal (relatively positive signal, for example) over line 42 which cause microprocessor 20 to exit the loop as a minimum output light power has been generated by laser 14.

At step 141, the line 37 is sensed to determine if it is still inactive. If the line 37 signal is active at step 142, then an error condition has occurred i.e., the maximum and minimum levels should not be the same. If the line 37 signal is inactive at step 142, then microprocessor 20 at step 144 stores the minimum level value (DACmin) in table 43 of RAM 21. Then microprocessor 20 enters an operations loop having steps 145-152 for finding the maximum power level as detected by switching comparator 35. Steps 145 and 146 respectively inactivate write data (reset flip-flop 90) and close switch 75.

In step 147, DAC 23 input value is increased by a predetermined number of units, such as 1, 2, or 3. Microprocessor 20 tallies the increases of DAC 23 steps and stores the tally in table 43. After the DAC input value has been increased, a time delay 148 occurs for allowing the laser system to settle to a steady-state condition. Steps 149 and 150 respectively open switch 75 and activate write data (set flip-flop 90). At step 151 microprocessor 20 senses line 37 for the active or inactive signal condition. If the line 37 signal is inactive at step 152, the loop is re-entered and repeated until line 37 become active. When the line 37 signal is active, microprocessor 20 in step 153 stores the current DAC 23 input value in table 43 as DACmax, in step 154 resets flip-flop 90 to inactivate write data and closes switch 75 in step 155. Then from step 155, microprocessor 20 proceeds to step 64 of Fig. 2 via line 156.

Fig. 5 is an abbreviated flow chart of normal microprocessor operations showing the detection of under and over power conditions. Microprocessor 20 has a known interrupt input. The line 102 signal is supplied to those microprocessor 20 real time interrupts having a high priority. As soon as a signal on line 102 activates the interrupt, such as at step 160, microprocessor 20 immediately turns its attention to that interrupt. At step 161, microprocessor 20 turns off laser 14 in response to the received interrupt. Then at step 162, the laser 14 can be re-calibrated to see if a momentary or intermittent condition occurred. If the recalibration is successful, then at step 163 a normal operation proceeds with an error being noted in an error log in a usual manner. If the recalibration is not successful, then a permanent error is set and laser 14 is turned off pending manual remedial actions.

Fig. 6 is a simplified diagrammatic plan view of a data storage disk 10 having an area 172 which stores nominal (recommended laser intensity) values for use in recording, erasing, and reading data from the disk 10. Such numbers can be provided at the time of manufacture of disk 10 and used by microprocessor 20 to calculate the DAC 23 digital input values for required laser output power levels for operating with a particular individual disk. Whenever a disk 10 having the calibration information in area 171 is loaded into a disk storage system, then during initialisation such information is read by microprocessor 20 for use in initial-

ising the storage system to the particular disk 10. In another aspect of the arrangement described, at time of manufacturing the Fig. 1 illustrated storage system, the DAC 23 can be calibrated in the factory. Such DAC efficiency calibration and calculation results can be stored in a long term retentive storage in PROM 171 for later use in the storage system. In subsequent DAC 23 efficiency calibrations, the newly obtained DAC efficiency value "E" is compared with the initial E value stored in PROM 171. Such comparison is useful in measuring changes in DAC 23 efficiency value E over time or with known operating conditions. When the limits are exceeded, then an error condition is signalled for manual intervention and remedial action. DAC calibration using the arrangement described detects such variations in operation of any optical data storage system or other optical device.

Claims

1. A control system for a light emitting device (14) comprising

   a control circuit (15) for controlling the emission of light from said device,

   a digital to analog converter (23) for generating analog signals for supplying to said control circuit (15) in order to control the intensity of said emitted light,

   means (20) for supplying digital signals to said digital to analog convertor in accordance with the required intensity of said emitted light, and

   calibrating means for calibrating said control system to account for variations in the parameters or the operational state of said system,

   characterised in that said calibrating means comprises

   means (20) for varying the digital signals supplied to said convertor until the intensity of the light emitted from said device is at a first, minimum level and storing the value of said digital signals as a first digital value,

   means (20) for varying the digital signals supplied to said convertor until the intensity of the light emitted from said device is at a second, maximum level and storing the value of said digital signals as a second digital value, and

   calculating means (20) for calculating from said stored digital values the change of light intensity (E) represented by a unit change of digital signal value.

2. A control system as claimed in Claim 1 characterised in that said calibrating means comprises

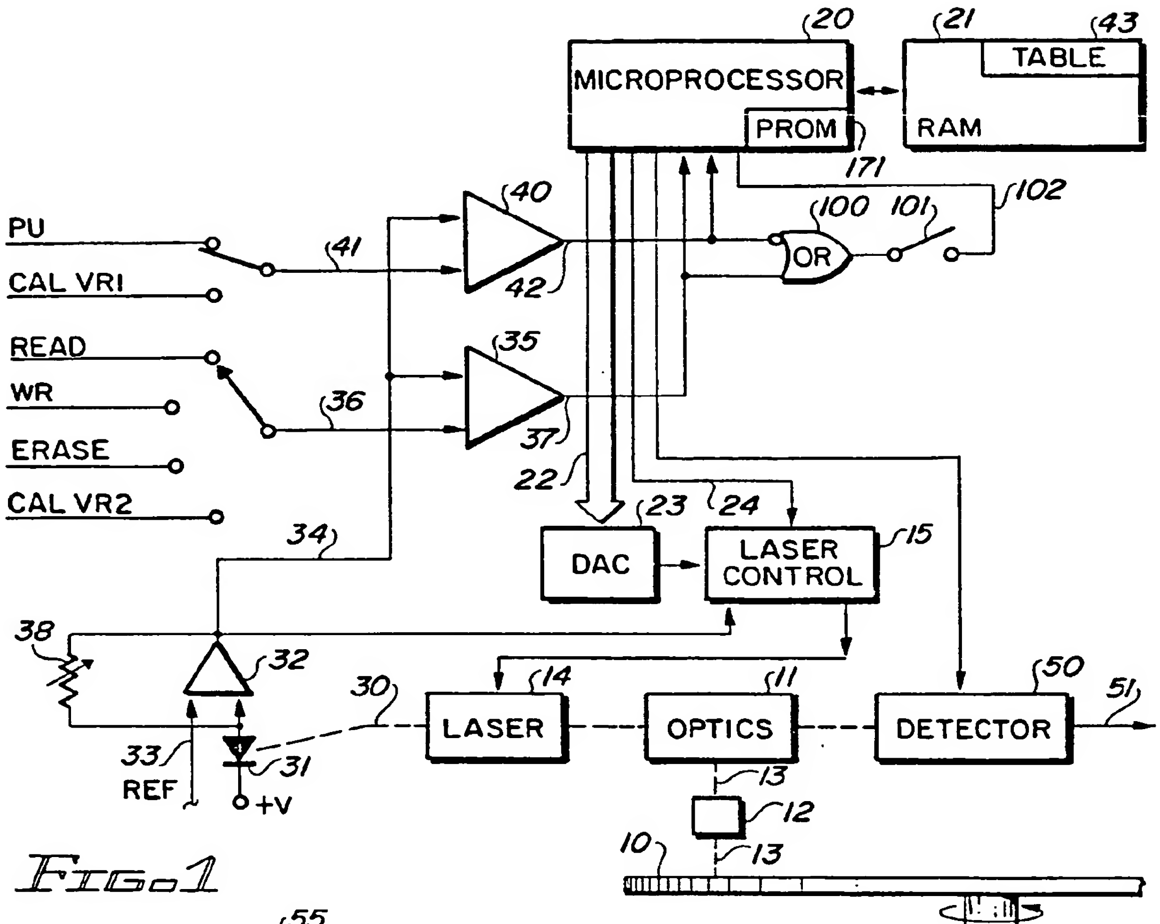
   means (20) for dividing the difference between said first and said second digital values by the difference between said maximum and minimum light intensity levels to calculate the value of E.

3. A control system as claimed in either of the preceding claims characterised in that calibrating means comprises

   means (30, 31, 32) for measuring the intensity of said emitted light while it is varied,

   first comparison means (40) for comparing said measured light intensity with a signal representing said minimum value and for supplying to said calculating means a first signal when said minimum value is not exceeded and a second signal when said minimum value is exceeded, and

   second comparison means (35) for comparing said measured light intensity with a signal representing said maximum value and for supplying to said calculating means a third signal when said maximum value is not exceeded and a fourth signal when said maximum value is exceeded.


MICROPROCESSOR
PROM
20
21
43
TABLE
RAM
171
40
100
101
102
OR
PU
CAL VR1
41
42
35
READ
WR
ERASE
CAL VR2
36
37
22
23
24
34
DAC
LASER CONTROL
15
38
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LASER
OPTICS
DETECTOR
33
REF
31
+V
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FIG. 1

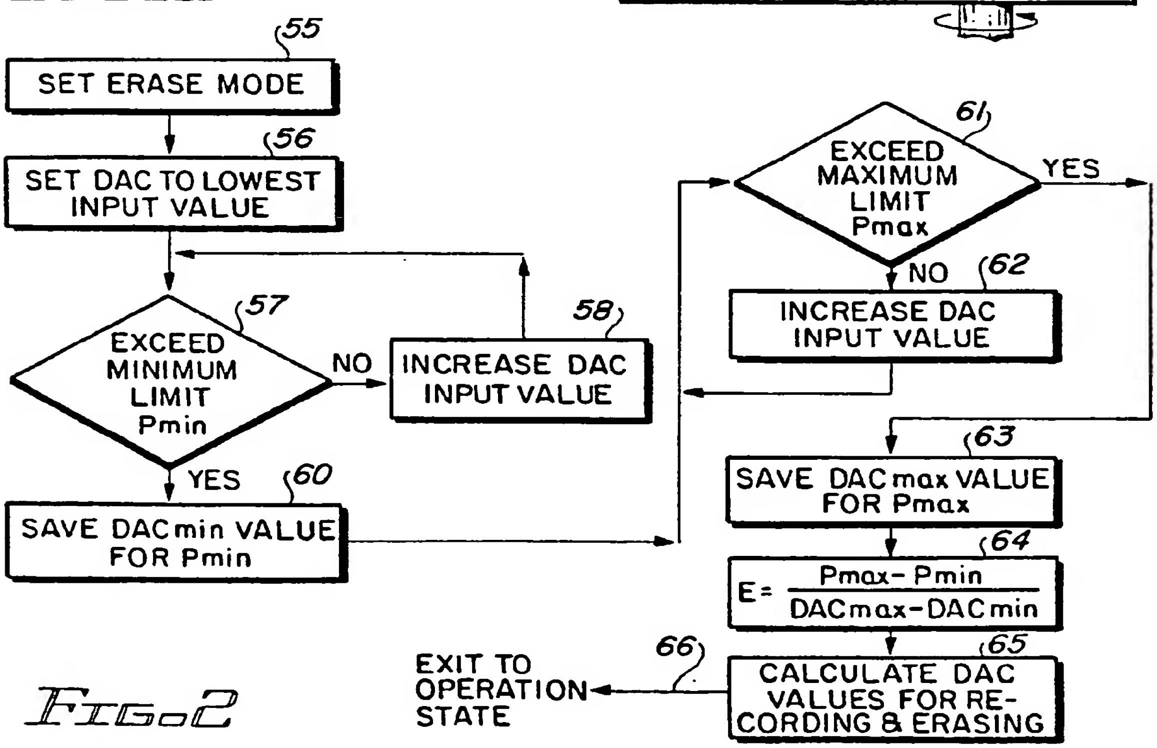
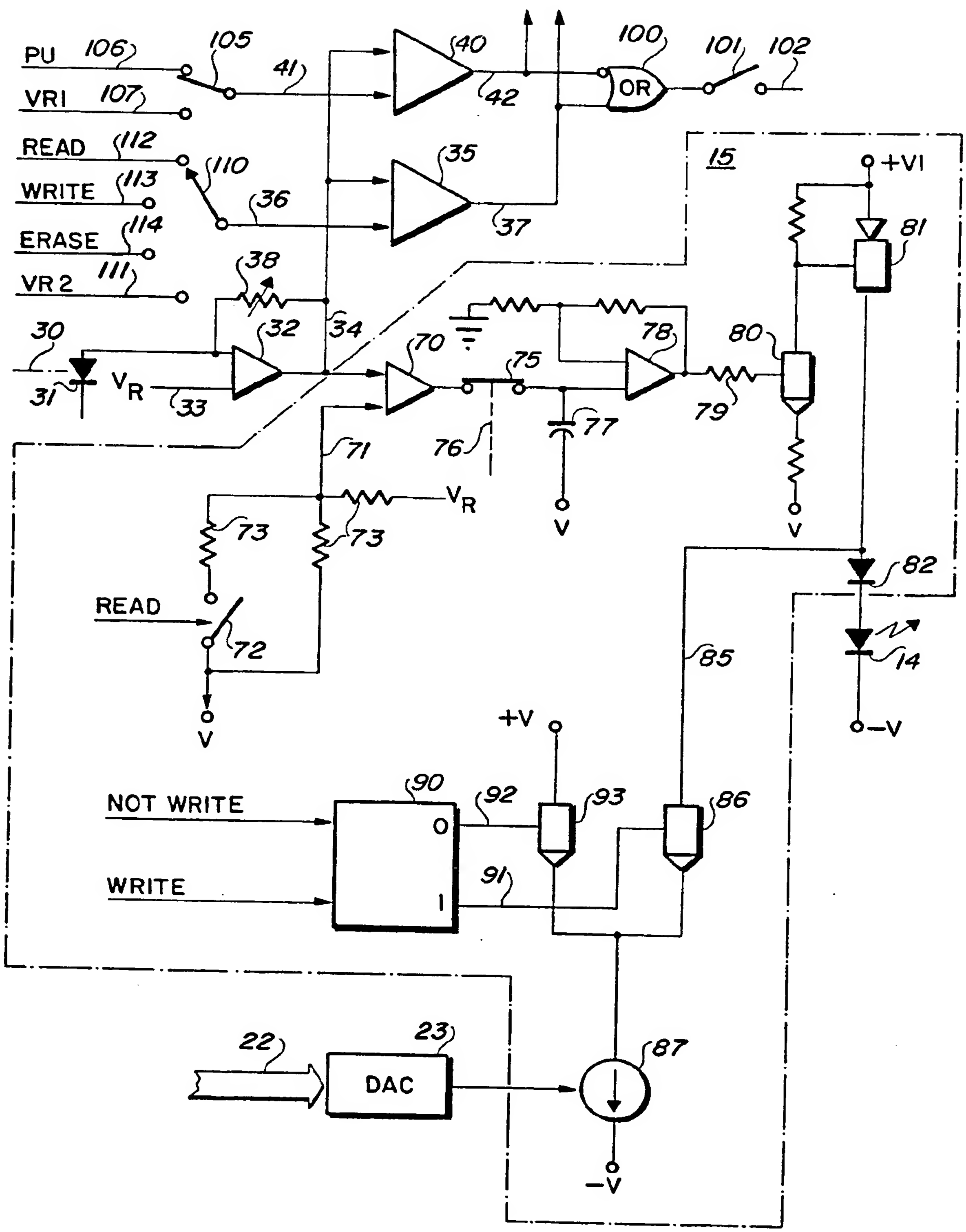

55
SET ERASE MODE
56
SET DAC TO LOWEST INPUT VALUE
57
EXCEED MINIMUM LIMIT Pmin
NO
58
INCREASE DAC INPUT VALUE
YES
60
SAVE DACmin VALUE FOR Pmin
61
EXCEED MAXIMUM LIMIT Pmax
YES
NO
62
INCREASE DAC INPUT VALUE
63
SAVE DACmax VALUE FOR Pmax
64
E = Pmax - Pmin / DACmax - DACmin
65
CALCULATE DAC VALUES FOR RECORDING & ERASING
66
EXIT TO OPERATION STATE

FIG. 2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101
102
VR1
107
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OR
READ
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35
15
+VI
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113
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37
ERASE
114
81
VR 2
111
38
34
30
32
70
78
80
31
V_R
33
75
79
76
77
71
V_R
73
73
V
V
82
READ
72
85
14
V
+V
-V
NOT WRITE
90
92
93
86
0
WRITE
91
1
22
23
DAC
87
-V

FIG. 3

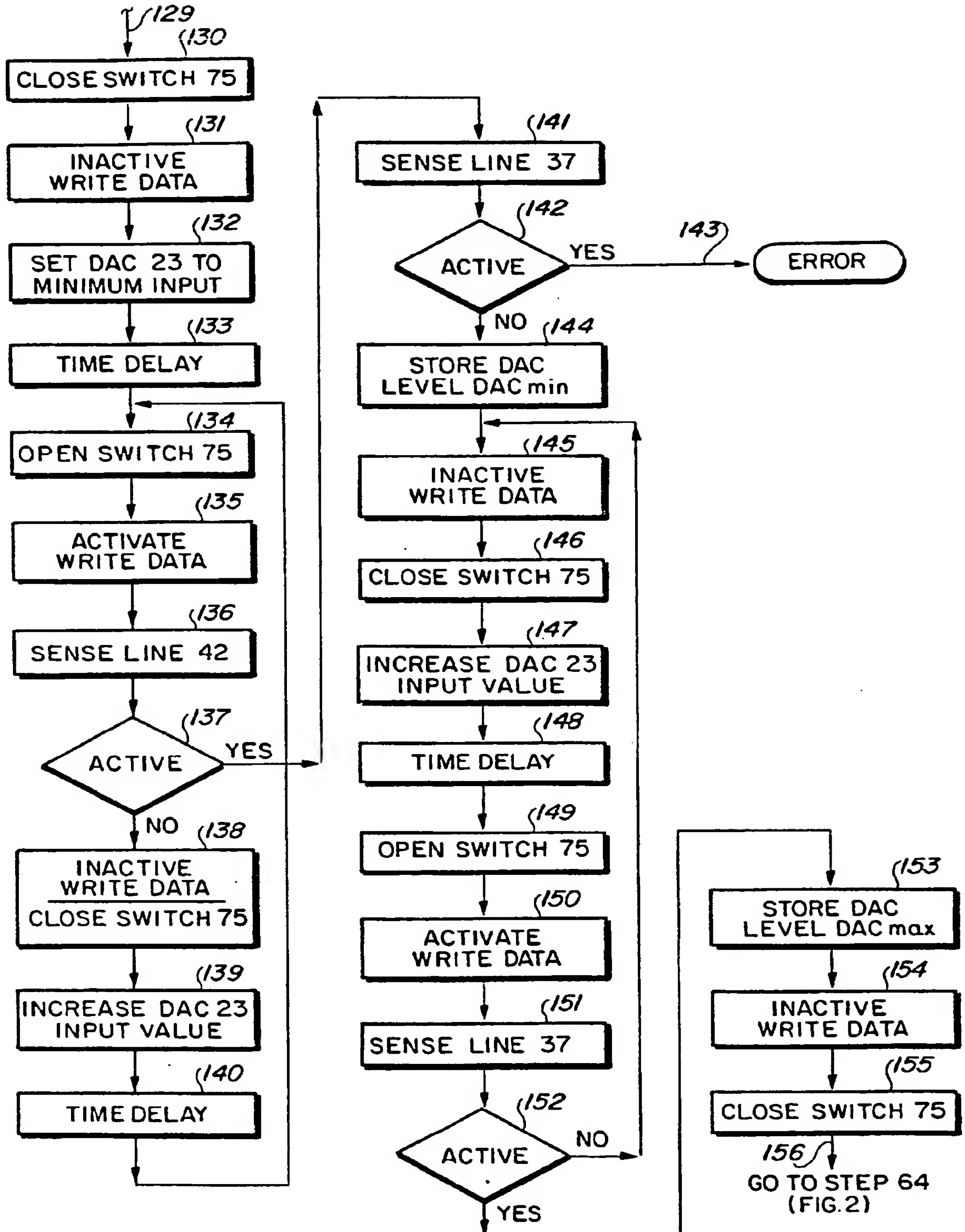
129
130
CLOSE SWITCH 75
131
INACTIVE WRITE DATA
132
SET DAC 23 TO MINIMUM INPUT
133
TIME DELAY
134
OPEN SWITCH 75
135
ACTIVATE WRITE DATA
136
SENSE LINE 42
137
ACTIVE
YES
NO
138
INACTIVE WRITE DATA
CLOSE SWITCH 75
139
INCREASE DAC 23 INPUT VALUE
140
TIME DELAY
141
SENSE LINE 37
142
ACTIVE
YES
143
ERROR
NO
144
STORE DAC LEVEL DAC min
145
INACTIVE WRITE DATA
146
CLOSE SWITCH 75
147
INCREASE DAC 23 INPUT VALUE
148
TIME DELAY
149
OPEN SWITCH 75
150
ACTIVATE WRITE DATA
151
SENSE LINE 37
152
ACTIVE
NO
YES
153
STORE DAC LEVEL DAC max
154
INACTIVE WRITE DATA
155
CLOSE SWITCH 75
156
GO TO STEP 64 (FIG.2)

FIG. 4

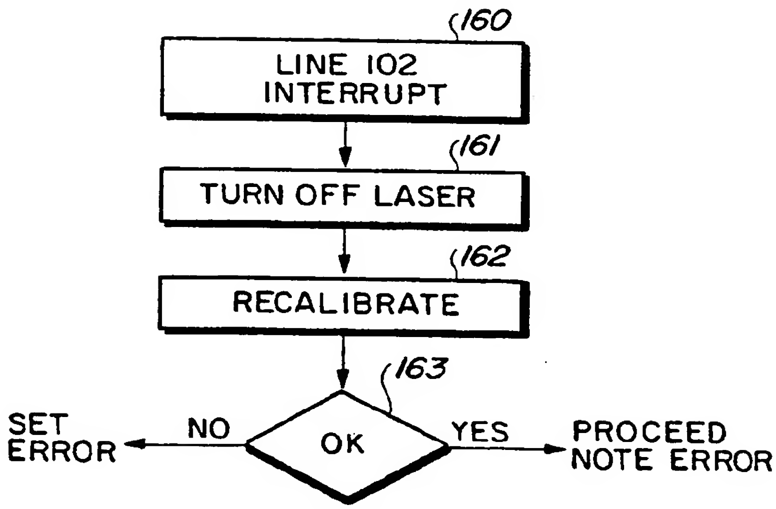
160
LINE 102
INTERRUPT
161
TURN OFF LASER
162
RECALIBRATE
163
SET
ERROR
NO
OK
YES
PROCEED
NOTE ERROR

FIG. 5

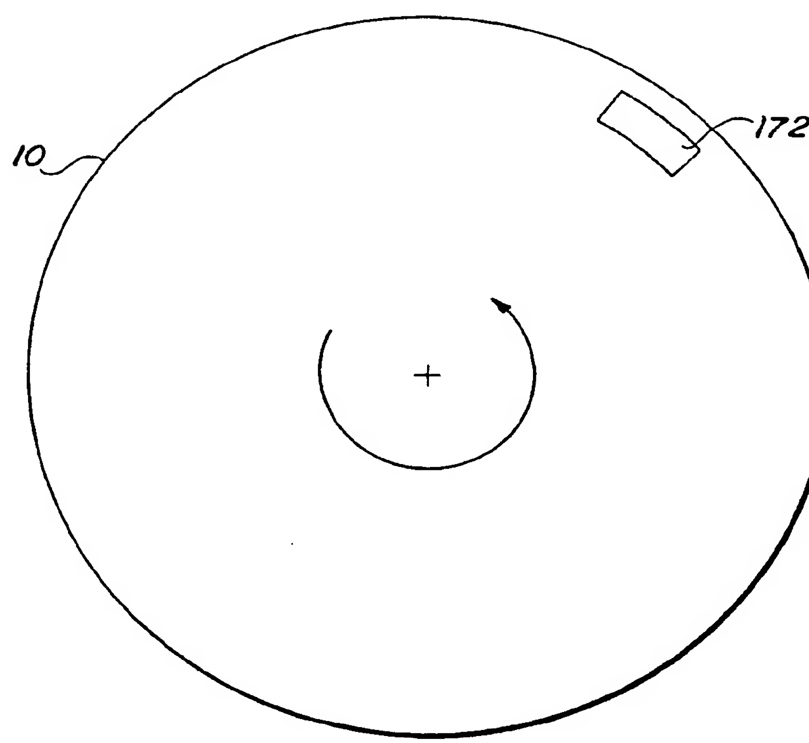
10
172

FIG. 6

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(54) control system for light emitting device.

(57) The present invention relates to a control system for a light emitting device (14) comprising a control circuit (15) for controlling the emission of light from the device, a digital to analog converter (23) for generating analog signals for supplying to the control circuit (15) in order to control the intensity of the emitted light, means (20) for supplying digital signals to the digital to analog convertor in accordance with the required intensity of the emitted light, and calibrating means for calibrating the control system to account for variations in the parameters or the operational state of the system.

According to the invention the control system is characterised in that the calibration means comprises means (20) for varying the digital signals supplied to the convertor until the intensity of the light emitted from the device is at a first, minimum level and storing the value of the digital signals as a first digital value, means (20) for varying the digital signals supplied to said convertor until the intensity of the light emitted from the device is at a second, maximum level and storing the value of the digital signals as a second digital value, and calculating means (20) for calculating from the stored digital values the change of light intensity (E) represented by a unit change of digital signal value.

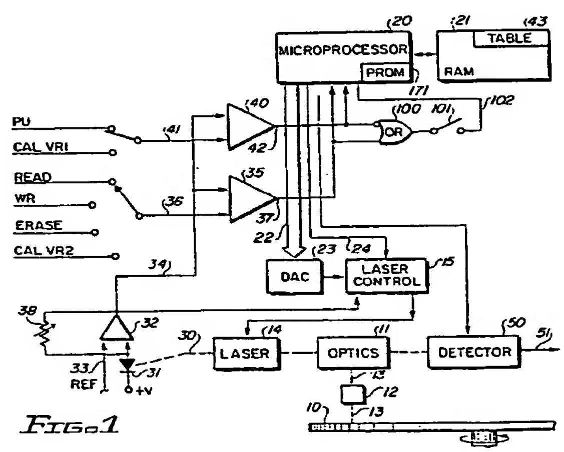

FIG. 1

EP 0 467 616 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 30 6379

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-0 352 125 (SHARP KABUSHIKI KAISHA) * the whole document *	1-3	H01S3/10 G11B7/125 H01S3/13 G12B13/00
X A	US-A-4 747 091 (DOI) *abstract* * column 1, line 42 - column 3, line 47; claims 1,2; figure 1 *	1 2,3	
D,A	US-A-4 503 467 (IDA) * the whole document *	1,2	
D,A	US-A-4 709 369 (HOWARD) * the whole document *	1	
A	EP-A-0 223 576 (FUJITSU LTD) * abstract; claims 1-3,5,6; figure 1 *	1-3	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H01S G11B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 JULY 1992	CLAESSEN L.M.

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